GENERAL ARTICLE

Termites and ants ecosystem: The potentially large source of greenhouse gases

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Methane (CH_4) and carbon dioxide (CO_2) are important greenhouse gases with different sources, whose concentrations in the atmosphere are increasing with time. One major uncertainty in the models of the present and future climate of the earth is the magnitude of emission of these trace gases. Termites and ants are omnipresent social insects in tropical, subtropical, and warm temperate regions of the world and they play an important role in ecosystems. Their thousands and millions of individuals live in a single colony with high coordination. They are also referred to as superorganisms or giant organisms and their combined biomass will be about twice the biomass of all living human beings on the earth (Hölldobler and Wilson 1994; Bar-On *et al.*, 2018). They emit significant quantities of CH_4 and CO_2 into the atmosphere as reported by different studies (Zimmerman *et al.,* 1982; Martius *et al.,* 1993; Dauber and Wolters 2000) but the range in published data is very large which gives ambiguity for their inclusion in global CH_4 and CO_2 budget.

Production of CH_4 and CO_2 in termites occurs as microbial degradation of ingested organic matter. The gut microbiota of lower termite initially breaks up cellulose to glucose monomers which in turn fermented to produce acetate, carbon dioxide, and hydrogen. Thereafter two competing processes occur, acetogenic bacteria reduce the carbon dioxide to another molecule of acetate, whereas methanogenic bacteria reduce the carbon dioxide into methane. The relative proportion of these two processes varies considerably among different species (Brauman *et al.,* 1992).

Studies on greenhouse gases emission by termites and ants

As reported by Zimmerman *et al.* (1982) termites directly emit large quantities of CH_4 (150 Tg y^{-1}) and CO_2 (50000 Tg y^{-1}) into the atmosphere and these laboratory estimation results were corroborated by field measurements of CH_4 emissions from two termite nests in Guatemala. They also estimated largest emission of CH_4 should occur in tropical areas disturbed by human activities. Another study in the Amazon rainforest reported that termites released CH_4 contributes approximately 5% of the annual global flux of CH_4 and estimated global termites mound emission 26 Tg y^{-1} (Martius *et al.,* 1993). The most recent estimates suggest termites contribute around 1 to 3% to the global CH_4 budget (Saunois *et al.,* 2016). Nonetheless, a new study finds that termite mounds oxidize, on average, about half of the termite CH_4 by methanotrophic bacteria living in the mound walls or soil beneath before releasing into the atmosphere (Nauer *et al.*, 2018). Nitrous oxide (N_2O) emissions were also detected in strong termite mounds (Brümmer *et al.,* 2009; Brauman *et al.,* 2015) especially if nitrogen-rich organic matter is available.

The nests of three ant species viz., *Myrmica scabrinodis, Lasius niger*, and *L. flavus* have 1.7 to 2.7 times greater CO_2 emission rate than non-ant influenced soil (Dauber and Wolters 2000). The CH_4 and CO_2 fluxes in forest soils are greatly affected by wood ant nests (Jílková *et al.,* 2015). A recent study finds that leaf-cutter ant, *Atta cephalotes* change the soil CO_2 dynamics by reducing nest soil CO_2 concentration and increasing total emissions. Nest soils accumulate less CO_2 than non-nest soils and these effects remain more than two years in abandoned nests. The ant nest vents emitted up to 100000× more CO_2 than the soil surface, and increased soil CO_2 emissions at the ecosystem level by 0.2 to 0.7% for a Neotropical wet forest (Fernandez-

Bou *et al.,* 2019). Similarly, Mehring *et al.* (2021) find that CO_2 and CH_4 fluxes from nest vents of leaf-cutter ant, *A. cephalotes* were significantly higher than non-nest fluxes, and these nest emissions may have important implications for the carbon budgets of tropical and subtropical American forests. The refuse piles created by leaf-cutting ants provide ideal conditions for extremely high rates of greenhouse gas N_2O production (high microbial biomass, potential denitrification enzyme activity, N content, and anoxia) as reported by Soper *et al.* (2019).

Conclusions

Studies have found that about all species of termites produce CH_4 and they contribute around 1 to 3% to the global CH_4 budget, but the range of CH_4 emissions in published data is strikingly large (0.9 to 150 Tg CH_4 y^{-1}). Most of the direct emission studies are not match with recent science, as they didn't consider the hidden biofilter mechanism present in termite mounds to mitigate CH_4 emission. More studies are required on different termites and ant species to estimate the production of greenhouse gases in different regions of the world by considering all scientific factors in their complex system. Based on presently published data we can't conclusively relate termites and ant's greenhouse gases emission with climate change.

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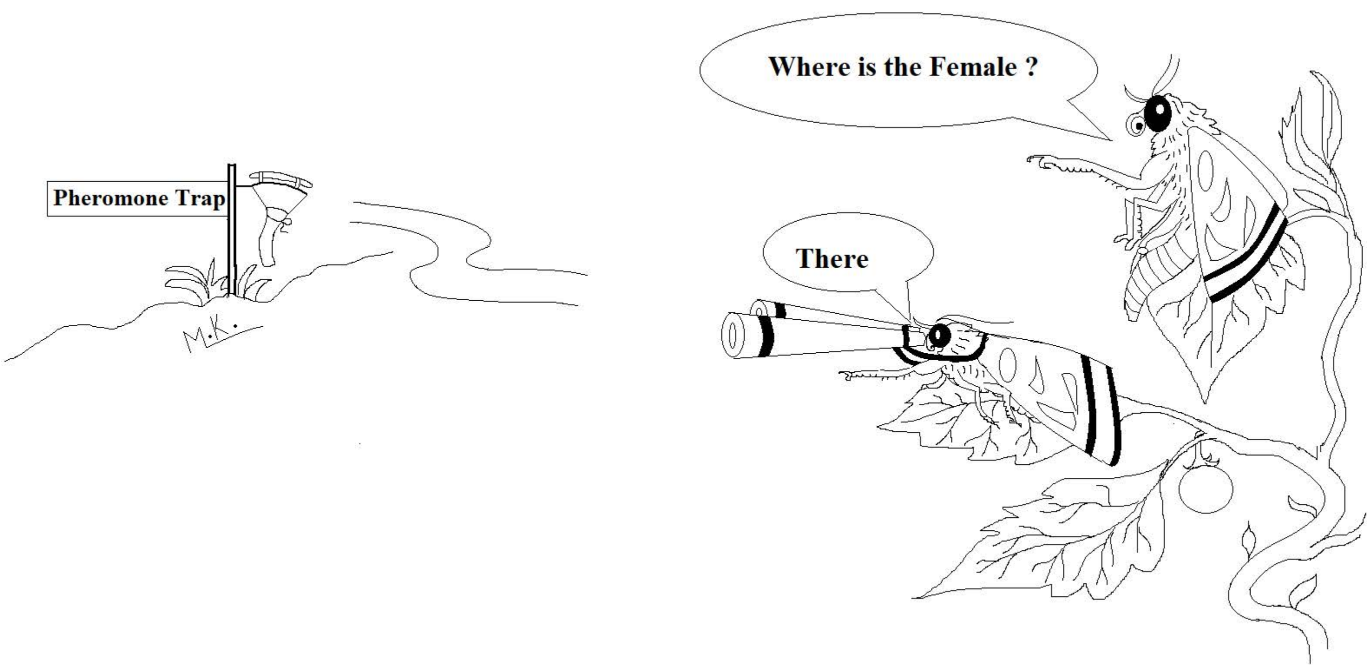

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